UNUSUAL FEBRUARY 2016 IN SLOVAK RIVER BASINS

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ABSTRACT

Extraordinary winter flood affected Slovak river basins in February 2016. The flood has been atypical for winter season. It was preceded by record high air temperatures, extremely high sums of precipitation and negligible snow water supplies. Despite the winter the flood was caused by rainfall. The Slaná and Ipeľ river basins were the most affected Slovak basins. From hydrological point of view the most important peak discharges were recorded on tributaries of the Slaná river basin – Turiec and Muráň.

Keywords: precipitation, winter flood, peak flow, ground water storage

1. INTRODUCTION

The floods in February are not unusual. Considering physical geography of Slovakia the most often causes of winter floods are heavy rain, frozen soil as well as transient warming accompanied by snow melting.

February 2016 was extremely warm with frequent occurrence of intense precipitation that was only in higher altitudes in the form of snow or mixed precipitation. With respect to statistics and the Slovak long-term spatial characteristics of air temperature and precipitation, mean monthly values of both temperature and precipitation were record – February 2016 was warmer than February 1966 and wetter than February 1977 [1].

Compared to that, the February 2016 mean monthly discharges were record only for stations with the beginning of observations after 1977. At hydrological stations with longer discharge time series and according to water bearing of stream February 2016 has ranked third after February 1966 and February 1977 respectively. Significant snow water storage was accumulated in all Slovak catchments before the floods in February 1966 and 1977. Sudden warming together with precipitation caused snowmelt runoff and significant increases of water levels. The flood wave volumes in February 1966 and 1977 were thus greater compared with flood in February 2016.

2. PRECIPITATION

The flows of relatively warmer and wetter air masses from the south to southwest were critical feature for weather patterns in February 2016 over the Slovak territory. In southwest flows individual frontal systems were formed and brought heavy rainfall.

February as the last winter month has been characterized by the lowest values of monthly precipitation sums with regard to long-term distribution of monthly precipitation. But February 2016 was exceptional by both rainfall totals and air temperature. Relating to precipitation it was above-average, in same river basins even extremely above-average. Figures 1, 2 show maps of monthly precipitation total and exceeding of long-term monthly values.

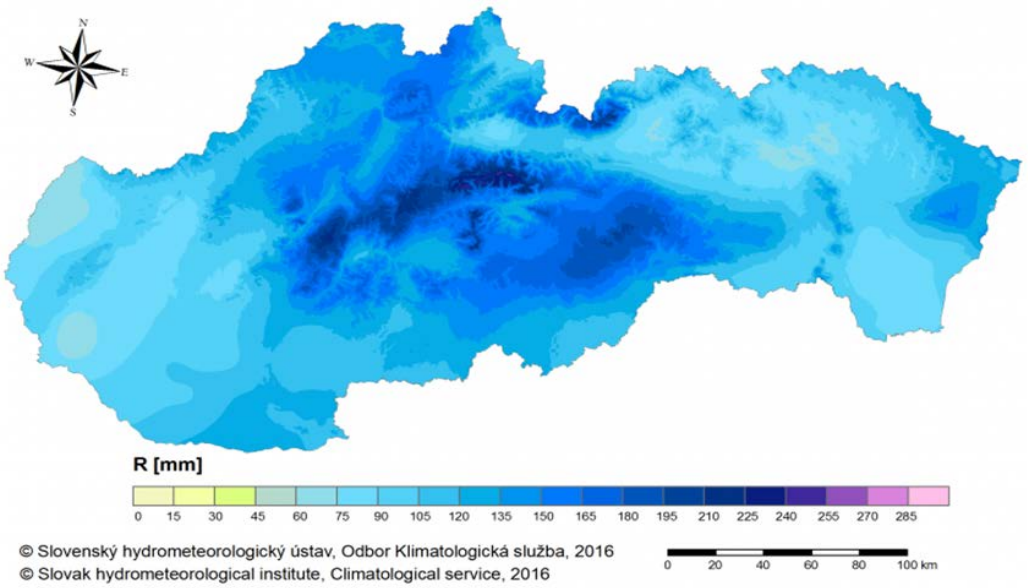

Fig. 1: Monthly precipitation total in Slovakia in February 2016

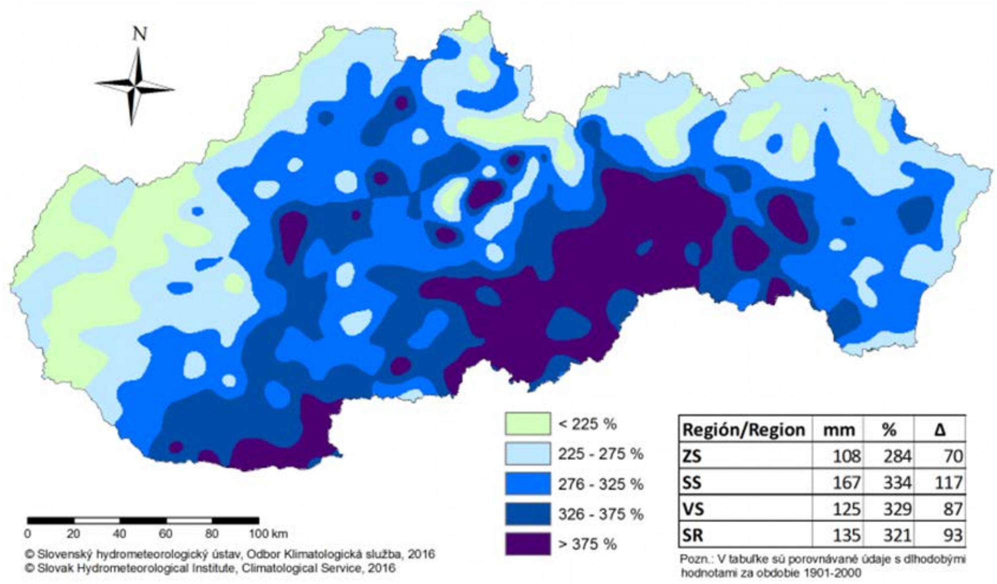

Fig. 2 Precipitation totals in Slovakia for February 2016 in % of 1961-1990 normal

Monthly mean precipitation total on the area of Slovak republic reached the value 135 mm, what represents 321 % of the long-term monthly precipitation total and abundance of precipitation 93 mm. Tab. 1 shows the mean monthly totals, percentages of long-term values as well as monthly abundances of precipitation in main river basins. The highest monthly mean precipitation total was recorded in the Slaná river basin. Long-term monthly precipitation total has been exceeded nearly four times.

Tab. 1: The mean monthly sums of precipitation in the Slovak main river basins

Main river basins	Monthly sums of precipitation [mm]	Percentage of long-term value 1961-1990	Abundance of precipitation [mm]
Morava (SK)*	85	217	+46
Dunaj (SK)*	111	324	+77
Váh	122	249	+73
Nitra	125	300	+83
Hron	152	314	+104
Ipeľ	134	367	+98
Slaná	156	397	+117
Bodva	123	375	+90
Hornád	109	335	+76
Bodrog	101	279	+65
Poprad	106	265	+66

* (SK) – Slovak part of river basin

The extreme of the situation in terms of precipitation is also evidenced by the fact that e.g. in rain gauge station Ábelová (the Ipeľ river basin) the long-term monthly precipitation total has been exceeded more than five times and in the next eleven rain gauge stations in the Ipeľ river basin more than four times.

Already in mid-February 2016 above-average to extreme precipitation was observed and normal monthly precipitation was exceeded in most rain gauge stations, in many of them more than two or three times. For example, 132,3 mm fell in station Revúca (the Slaná river basin) up to February 16. Until then the highest monthly total had value 110,3 mm and was recorded in 2013. Accumulated daily precipitation totals over the Slaná river basin are in the figure 3.

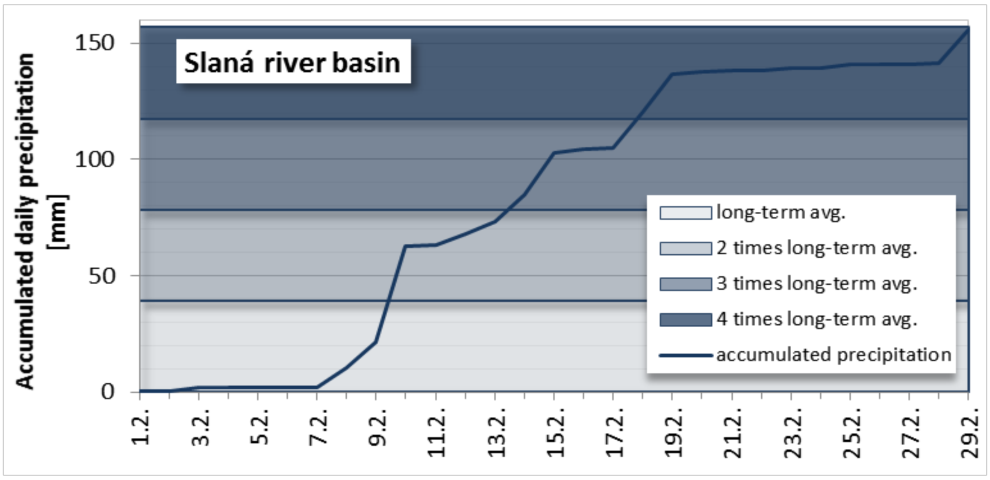

Fig. 3 Accumulated daily precipitation totals in the Slaná river basin in February 2016 (long-term avg. is 1961-1990 normal for February)

Precipitation activity itself has concentrated on several rainfall events. The first and most significant hit the Slovak territory on February 8 – 10. The highest 3-day rainfall totals were 60 – 70 mm, in extreme occasions about 90 mm.

The most intense precipitation was observed on February 10. In 24 hours, normal monthly precipitation has been exceeded significantly in some regions, especially in regions of Banská Bystrica and Košice. The highest daily sums over 50 mm were observed in the Slaná river basin (max. 61,6 mm in Nižná Slaná). In Slovak physical geographic conditions, such high values are typical for summer convective rainfall more than for winter long-lasting precipitation.

Extraordinary precipitation has been reflected in flood situation in most of Slovak main river basins. Degrees of flood activity have been exceeded in many hydrological stations.

Second precipitation event followed on February 12 – 16 and the last one on February 18 – 21. Precipitation totals were not as high as in the beginning of February. The highest multi-day rainfall totals reached 40 – 60 mm. The combination of causal precipitation and antecedent basin saturation after previous flood events caused new flood waves.

The evolution of flood events was significantly influenced by state of matter of precipitation. Despite the winter season liquid precipitation prevailed. Only in high mountains regions, part of the causal precipitation occurred as snow which accumulated and did not contribute to direct runoff. Precipitation during particular events has been distributed equally in space and time and the highest intensities of hourly precipitation have reached 5 to 6 mm (fig. 4).

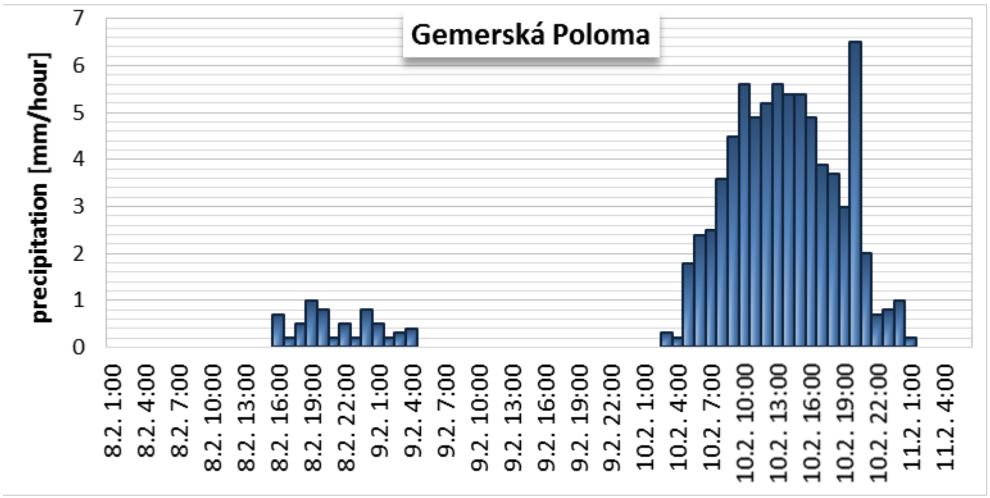

Fig. 4 Intensities of hourly precipitation in rain-gauge station Gemerská Poloma (the Slaná river basin) on February 8 – 11, 2016

3. HYDROLOGY

Although the major cause of the flood situation was due to heavy atmospheric precipitation, its transformation into the flow was favorably influenced by other climatic factors – mainly by time and spatial distribution of precipitation, 1 to 2 days without precipitation after each precipitation event, type of precipitation, snow cover and depth of frozen soil. In the Hron and the Vah river basins, some precipitation fell in higher elevations in the form of snow and accumulated. It did not participate in direct runoff, making the flood situation more favorable.

The river basin saturation before the first, at many places significant flood situation, was low. The spatial analysis of the river basin saturation on the morning February 7, 2016 based on the Antecedent Precipitation Index (API) is shown in figure 5.

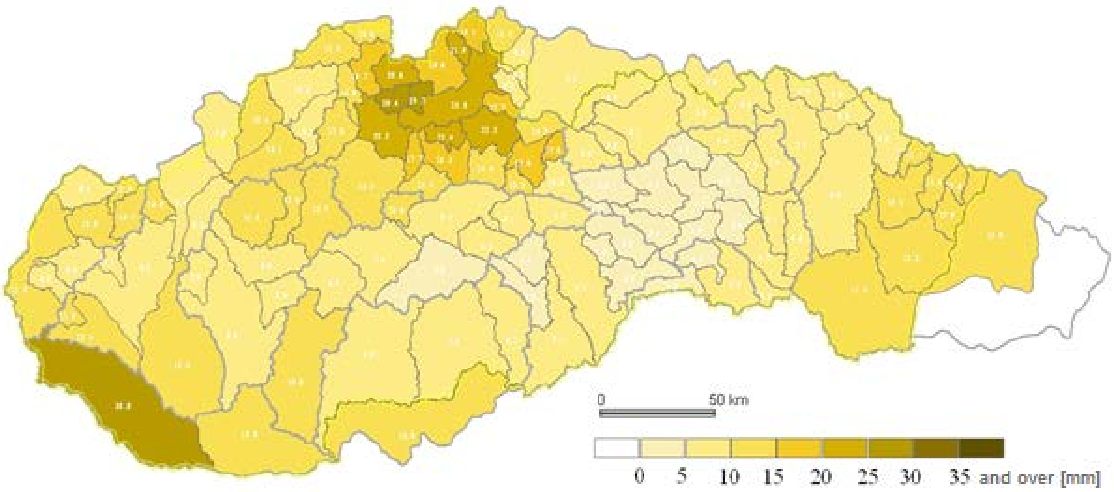

Fig. 5 Average Antecedent Precipitation Index (API) on February 7, 2016 at 6:00 CET

Water levels started to rise on February 8 and significant increases were observed on February 10. In most tributaries and upper parts of the main river basins, the February peak levels were recorded on February 10 and 11. Discharge wave in Gemerská Ves on the Turiec River with marked N-year flood discharges and the water levels in Bretka on Muráň River with marked levels corresponding to the level of flood activity are in figure 6 and 7. In this two water stations hydrologically the most significant maximum peak discharges of February 2016 flood were recorded.

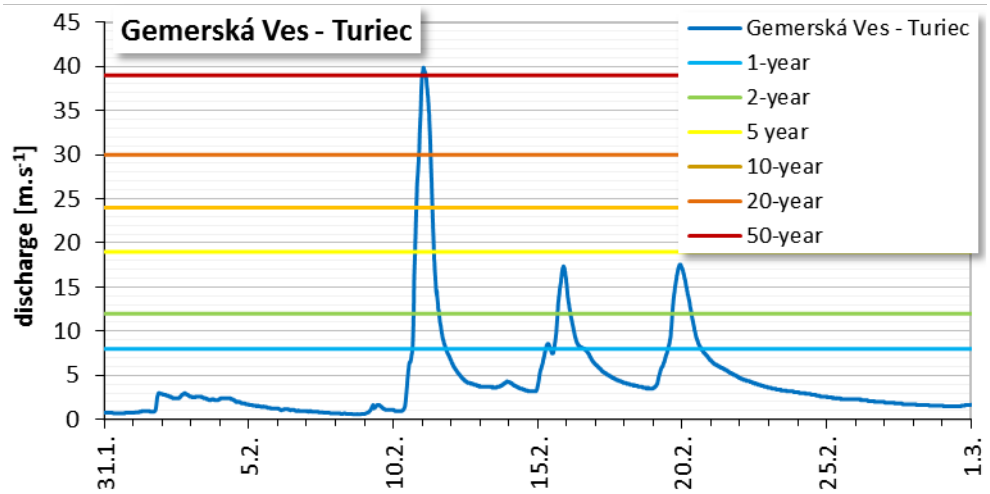

Fig. 6 Course of 15-min discharges in Gemerská Ves on Turiec River in Slaná river basin in February 2016 with marked N-year flood discharges

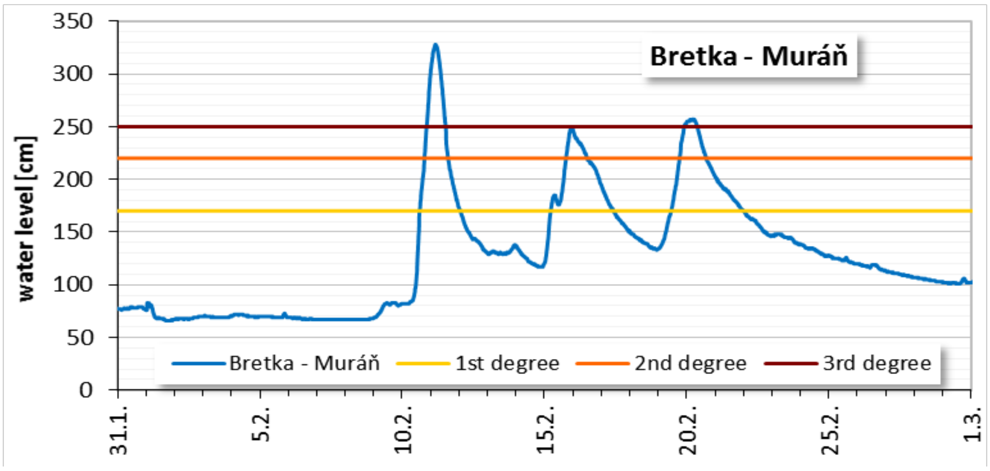

Fig. 7 Course of 15-min water levels in Bretka on Muráň River in Slaná river basin in February 2016 with marked levels corresponding to the degree of flood activity

Groundwater water levels also had a positive impact on the development of the hydrological situation. The flood situation generally means an intensive feeding of the groundwater through the flood waters. Groundwater levels in Slovakia have been decreasing practically from July to October 2015. Since November 2015, there was only a marginal slow replenishment of the groundwater. But already in first days of the

February flood, along with the onset of flood waves, there was a significant replenishment of the groundwater in the inundation river zones and after a short time, the groundwater levels reached their maximum. During this flood event the groundwater levels reached their maximum levels in the hydrological year 2016 (Gemerská Ves – Hrkáč well, figure 8). In the inundation river zones they reached only a few centimeters below the surface, at some places they even got on the ground. Changes in groundwater levels from selected well as well as the direct influence of groundwater level from the surface flow are shown in figure 9.

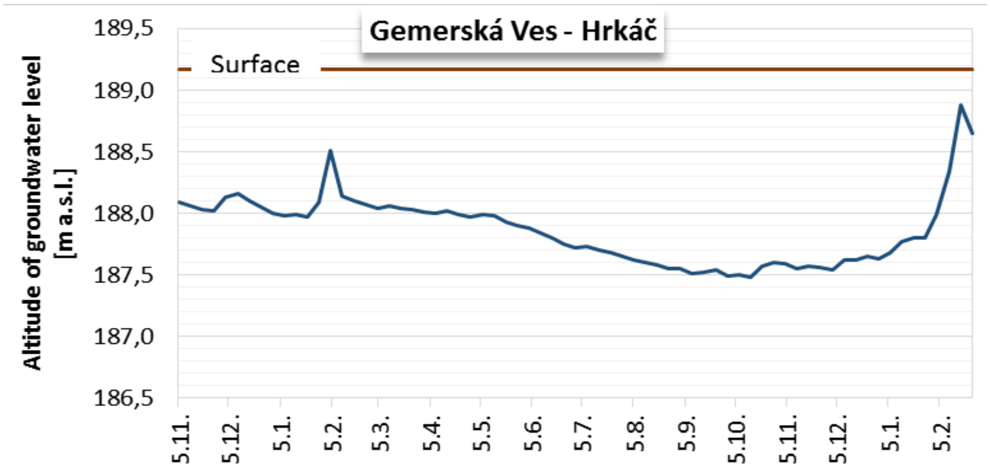

Fig. 8 Altitude of groundwater level in Gemerská Ves – Hrkáč well in Slaná river basin form November 2014 to February 2016

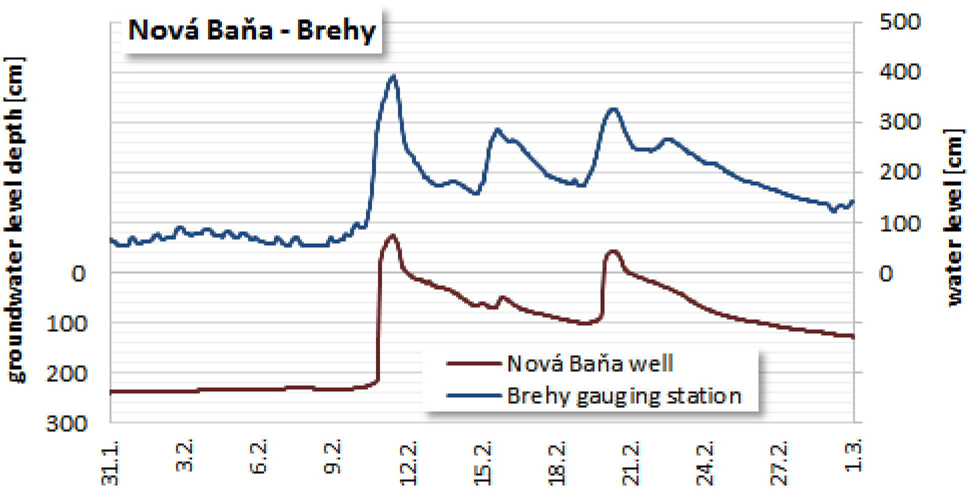

Fig. 9 The courses of groundwater level depth from the terrain level and water levels in selected objects of underground (Nová Baňa well) and surface water (Brehy gauging station) in the Hron river basin in February 2016

Relatively even distribution of precipitation in time and space, mainly positive soil temperature and also low groundwater levels before the flood favorably influenced the retention characteristics of the river basins and the runoff evolution as well. The volume of precipitation contributing to the direct runoff has decreased. It positively affected the flood situation because of decreasing the peak flow. Great amount of precipitation was resulted in replenishing the groundwater in a hydraulic connection with the surface flows.

Although in terms of probability of exceedance February maximum peak discharges did not reach historic values, unlike precipitation and air temperature, the extraordinary nature of February 2016 flood is noticeable in its duration and spatial extent. Except the Poprad river basin, all Slovak catchments were affected. The maximum peak discharges were evaluated mostly as the 1-2 year flood discharges. In the Bodrog and Hornád river basins maximum peak flows did not reach 1-year flood discharge. Hydrologically most significant maximum peak discharges occurred on February 10 and 11 in the Slaná river basin, on tributaries Turiec and Muráň Rivers. The value of maximum peak discharge in Gemerská Ves on Turiec River reached the significance of 50-year flood discharge, in Behynce 20-year and in Bretka on Muráň River 10-year flood discharge (Fig. 10). These were the second highest peak flows during the observation period at these hydrological stations, the values from flood year 2010 were not attained. Maximum water levels exceeded levels corresponding to the 1st to 3rd degrees of flood emergency activity in the most operational hydrological stations (Fig. 11). The flood emergency situation lasted from February 10 to February 29, 2016.

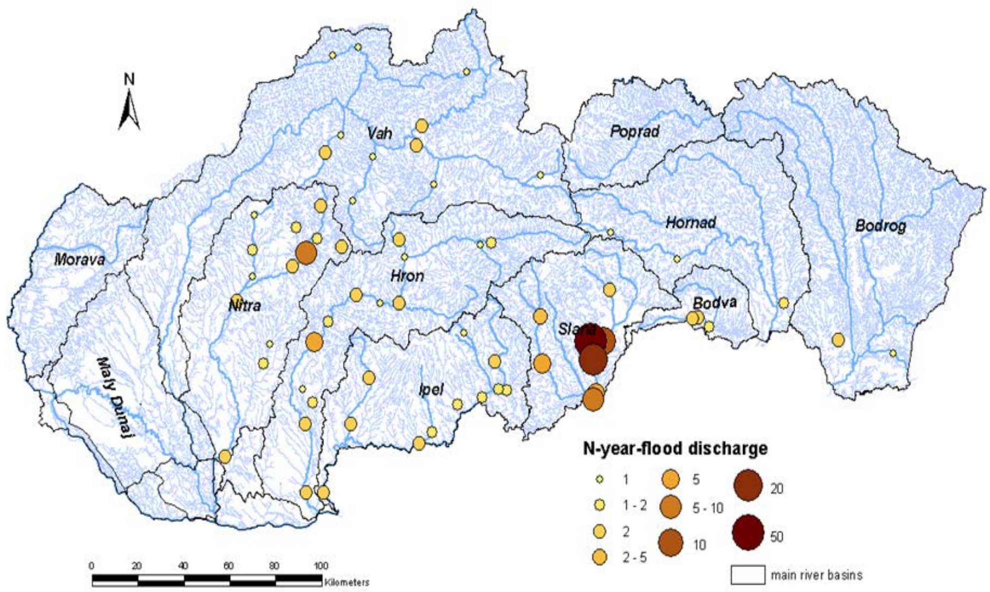

Fig. 10 Map of N-year maximum peak discharges in February 2016 at hydrological stations where levels correspond to a flood activity

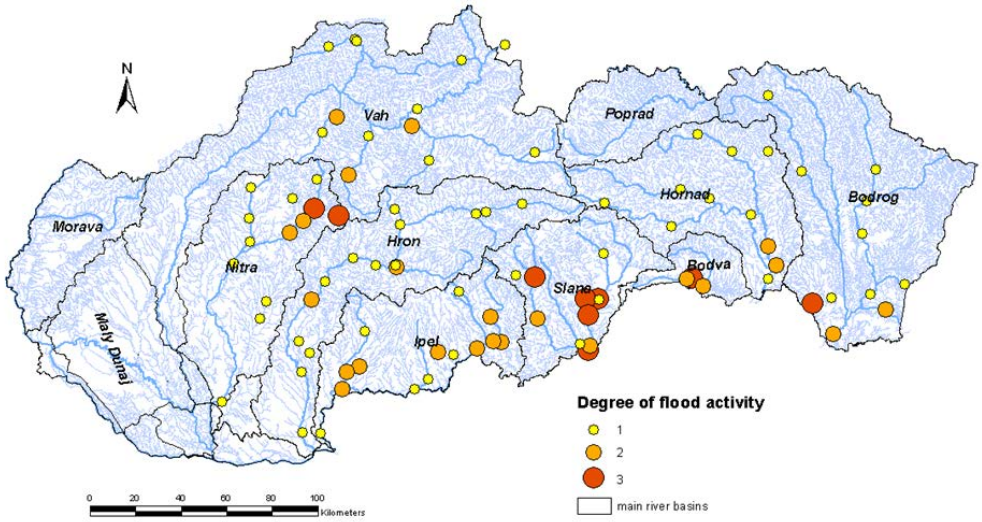

Fig. 11 Map of operation hydrological stations where the maximum water levels reached and exceeded levels corresponding to the 1st to 3rd degree of flood activity.

4. CONCLUSION

The February flood hit almost all catchments whose rivers spring in the Slovak territory. The flood was unusual mainly due to the fact that, in spite of the winter, the main cause was liquid precipitation without the contribution of melting snow. Relatively even distribution of precipitation in time and space, mainly positive soil temperature and also low groundwater levels before the flood favorably influenced the retention characteristics of the river basins and the runoff evolution as well. The volume of precipitation contributed to direct runoff has decreased and as a result of this, peak flows have been reduced. With regard to probability of exceedance peak flows did not reach historic values as in the case of precipitation and air temperature. The exceptionality of the February flood was in its duration and spatial extent.

5. REFERENCES

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